

*Fig. 9. Cyrtophium cristatum* ♂, magnified.

*Fig. 10.* The same : mandible, × 28.

*Fig. 11.* The same : left maxilliped, × 28.

*Fig. 12.* The same : first gnathopod, × 28.

*Fig. 13.* The same : second gnathopod, × 25.

*Fig. 14.* The same : single hair from palm of same, × 115.

*Fig. 15.* The same : telson and posterior pleopoda, three pairs, × 28.

XXXVIII.—*On the Geological Distribution of the Rhabdophora.* By CHARLES LAPWORTH, F.G.S. &c.

[Continued from vol. iii. p. 455.]

Part II. DATA.

CAMBRIAN SYSTEM.—Although the fact of the existence of Cladophora in the Upper Cambrian rocks has been admitted by palæontologists since Salter's discovery of *Dictyonema sociale* in such abundance in strata of this age in Merionethshire, it is only within the last few years that the presence of Rhabdophora or true Graptolites in these ancient deposits has been placed absolutely beyond question. Kjerulf, indeed, figured a well-marked *Dichograptus* (*Bryograptus*) from the Alum-shales of Christiania in his 'Veiviser,' as early as 1865; but its exact horizon is even yet doubtful. Its true Cambrian age, however, is rendered highly probable by Linnarsson's more recent discovery of *Dichograptus tenellus* &c. in the highest Olenus-beds of Westrogothia\*, and an allied form in the *Dictyonema*-schists of Scania. These strata correspond to the highest portions of the Lingula-flags of Wales, and are unequivocally of true Cambrian age.

The question of the existence of Rhabdophora in the Upper Cambrian of Britain has also been satisfactorily set at rest by the interesting researches of Dr. C. Callaway. This careful observer detected Graptolites in the Shineton (Upper Cambrian) shales of Salop as early as 1873; and in the following year examples of *Bryograptus* and *Clonograptus* from these rocks were forwarded by him to me for identification; and I recognized at once their striking similarity to the forms figured from the Swedish Cambrian by Kjerulf and Linnarsson. Within the last few months Dr. Callaway has discovered fragments of the first of these genera in the Cambrian rocks of the Malvern Hills.

\* Linnarsson, 'Öfversigt af Vetenskaps-Ak. Förhandlingar,' 1871, p. 794; and Geol. Mag., June 1876.

ORDOVICIAN OR LOWER SILURIAN SYSTEM.—Notwithstanding the great additions made of late years to our knowledge of the fossils of the rich graptolitiferous zones of the Llandovery and Wenlock formations, Salter's well-known generalization that Murchison's Lower Silurian system is most prolific in Graptolites remains practically undisturbed. The Arenig formation also, though it can no longer be defined as the birthplace of the family, must still be acknowledged as its metropolis; for if we have respect to the abundant extra-British forms detected in this formation, it must be conceded that "nowhere else are there so many species and such complex forms"\*. This may, it is true, be owing to the fact that not only in Britain, but also in Europe and America the rocks of Arenig age are essentially dark carbonaceous shales or schists more or less graptolitiferous throughout; while the succeeding formations are marked by a much greater development of sandstones and limestones, from which, as a rule, Graptolites are absent. Nevertheless, even where black shales crowded with Graptolites do occur in these more recent formations, we never find so great a variety of types as upon any single horizon in the Arenig; and it may be that the Rhabdophora (like the Cladophora) had their culmination at or near the commencement of the Arenig, the loss, especially in genera, being very rapid as we pass upwards into the Llandeilo and Bala.

### *Arenig Formation.*

The only Welsh rocks belonging to this formation as yet carefully searched for Graptolites are the Arenig rocks of the neighbourhood of St. David's, familiar to geologists through the extended researches of Dr. H. Hicks. The three sub-groups into which the strata of this age are there divisible all yield Rhabdophora in some abundance. The forms recognized by Mr. Hopkinson and myself include †:—

#### I. Lower Arenig.

Didymograptus extensus, <i>Hall.</i>	Phyllograptus stella, <i>Hopk.</i>
— pennatulus, <i>Hall.</i>	Trigonograptus truncatus, <i>Lapw.</i>
— sparsus, <i>Hopk.</i>	— ensiformis, <i>Hall.</i>

#### II. Middle Arenig.

Didymograptus patulus, <i>Hall.</i>	Tetragraptus serra, <i>Brongn.</i>
Tetragraptus Halli, <i>Hopk.</i>	— quadribrachiatus, <i>Hall.</i>
— ? Hicksi, <i>Hopk.</i>	Clematograptus implicatus, <i>Hopk.</i>

\* Quart. Journ. Geol. Soc. vol. xix. pp. 119 *et seq.*

† Hopk. & Lapw. Quart. Journ. Geol. Soc. vol. xxxi. p. 634.

## III. Upper Arenig.

Didymograptus bifidus, <i>Hall</i> .	Dicellograptus divaricatus?, <i>Hall</i> .
— affinis, <i>Nich</i> .	Climacograptus confertus, <i>Lapw</i> .
— indentatus, <i>Hall</i> .	Diplograptus dentatus, <i>Brongn</i> .
— Nicholsoni, <i>Lapw</i> .	Glossograptus ciliatus, <i>Emm</i> .
— patulus, <i>Hall</i> .	

Some of the same forms occur in the corresponding Arenig rocks of Merionethshire. In the Jermyn-Street Museum the following forms are labelled as having been collected from the Upper Arenig of Tyobry near Tan-y-Bwylch\* :—

Diplograptus tricornis, <i>Carr</i> .	Glossograptus ciliatus, <i>Emm</i> .
— bimucronatus, <i>Nich</i> .	Diplograptus foliaceus, <i>Murch</i> .
Climacograptus confertus, <i>Lapw</i> .	— angustifolius, <i>Hall</i> .

The Arenig rocks in the neighbourhood of Shelve yield *Rhabdophora* in some abundance. From the lowest zones near the Bog Mine I have collected forms of *Phyllograptus*, *Didymograptus*, and *Trigonograptus*. In the Middle Arenig near Shelve church Mr. Hopkinson has detected † *Didymograptus patulus*, Hall, and *Clematograptus implicatus*, Hopk. I have found some of the same forms at Ladywell Mine, Disgwyllfa &c. From the Upper Arenig of Ritton Castle I have collected *Didymograptus Nicholsoni*, Lapw., and *D. patulus*, Hall. *Didymograptus constrictus*, Hall, is not uncommon in similar strata near Snailbeach.

*Lake District*.—The Arenig rocks of the Lake District include the Skiddaw Slates of Sedgwick. Little is yet known with certainty with respect to their proper physical and palæontological subdivisions. At present it is only possible to regard them, with Prof. Nicholson, as forming two main groups—a lower group of dark flagstones and shales, and an upper group of black shales and mudstones. Their Graptolites have been made the subjects of special memoirs by Salter and Nicholson; but the remarkably intertwined character of the two supposed subfaunas renders it more than probable that we have yet much to learn with respect to the systematic places of the several fossiliferous horizons.

From the Lower Skiddaw Rocks the following species have been collected ‡ :—

Loganograptus Logani, <i>Hall</i> .	Schizograptus reticulatus, <i>Nich</i> .
Temnograptus multiplex, <i>Nich</i> .	Ctenograptus annulatus, <i>Nich</i> .

\* Collection, Museum, Jermyn Street, case iv. |  $\frac{1}{14}$ ,  $\frac{1}{15}$ , &c. &c. Compare also Salter, Mem. Geol. Survey, vol. iii. p. 256 &c.

† Quart. Journ. Geol. Soc. vol. xxxi. p. 636.

‡ Nicholson, Ann. & Mag. Nat. Hist., October 1839; Quart. Journ. Geol. Soc. vol. xxiv. p. 125 &c.

Dichograptus octobrachiatus, <i>Hall.</i>	Didymograptus bifidus, <i>Hall.</i>
— Sedgwicki, <i>Salter.</i>	— Nicholsoni, <i>Lapw.</i>
Tetragraptus Headi, <i>Hall.</i>	— affinis, <i>Nich.</i>
— quadribrachiatus, <i>Hall.</i>	Phyllograptus typus, <i>Hall.</i>
— bryonoides, <i>Hall.</i>	— angustifolius, <i>Hall.</i>
— crucifer, <i>Hall.</i>	Diplograptus Hopkinsoni, <i>Nich.</i>
Didymograptus patulus, <i>Hall.</i>	— mucronatus?, <i>Hall.</i>
— gibberulus, <i>Nich.</i>	Azygograptus Lapworthi, <i>Nich.</i>
— nitidus, <i>Hall.</i>	

The various species of *Monograptus* (*Graptolithus*\*) quoted by Salter and others from the Skiddaw series are almost certainly merely fragments of compound genera. The *Graptolithus latus* of McCoy † was certainly of this nature; and the *Graptolithus tenuis*, *G. Nilssonii*, and *G. sagittarius* of Salter may with safety be assumed to have had a similar origin. His *Didymograptus sextans* (*Dicellograptus*?) is equally dubious. His *Diplograptus pristis* could not have been Hisinger's species, but was possibly *Diplograptus serra* (Brongn.) or some allied biserial form.

From the Upper Arenig rocks of Ellergill &c. Professor Nicholson has collected ‡:—

Trigonograptus lanceolatus, <i>Nich.</i>	Didymograptus geminus, <i>His.</i>
Trichograptus fragilis, <i>Nich.</i>	— fasciculatus, <i>Nich.</i>
Didymograptus patulus, <i>Hall.</i>	Glossograptus armatus, <i>Nich.</i>
— bifidus, <i>Hall.</i>	Phyllograptus angustifolius, <i>Nich.</i>
— affinis, <i>Nich.</i>	Diplograptus serra, <i>Brongn.</i>

To these I have myself added

Diplograptus tricornis, <i>Curr.</i>	Azygograptus cœlebs, <i>Lapw.</i>
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and species of *Climacograptus*.

*Scandinavia*.—The Lower Ordovician rocks of Sweden which correspond to our British Arenig are the so-called *Lower Graptolite-* or *Phyllograptus-Schists* that underlie the well-known *Orthoceras-Limestone*. Their included *Rhabdophora* have recently been carefully worked out by Mr. Linnarsson; but the majority of the forms he has discovered are as yet undescribed. In the various collections from these beds which I have up to this date had an opportunity of examining I have recognized §:—

Tetragraptus bryonoides, <i>Hall.</i>	Didymograptus constrictus, <i>Hall.</i>
— fruticosus?, <i>Hall.</i>	— strictulus, <i>Linnrs.</i>
— quadribrachiatus, <i>Hall.</i>	Phyllograptus angustifolius, <i>Hall.</i>
Didymograptus patulus, <i>Hall.</i>	Temnograptus multiplex?, <i>Nich.</i>

\* Salter, Quart. Journ. Geol. Soc. vol. xix. p. 135 &c.

† Quart. Journ. Geol. Soc. vol. iv. p. 223.

‡ Nicholson, *loc. cit. supra*.

§ Compare Linnarsson, Geol. Mag., June 1876.

Dr. Tornquist has identified, in addition, *Didymograptus extensus*, Hall, *Didymograptus affinis*, Nich., and *Phyllograptus typus*, Hall. To these Mr. Linnarsson has recently added representatives of *Didymograptus v-fractus*, Salt., *Trichograptus multiplex*, Nich., *Diplograptus Hopkinsoni*, Nich.

The dark shales that succeed to the Cambrian rocks of the neighbourhood of Christiania in Norway, and include the local representative of the Orthoceras-Limestone of Sweden, have long been known to be graptoliferous. A few of the Rhabdophora of these beds have been figured by Boeck † and Scharenberg ‡; but the horizons of the species are unknown. The forms named below may be easily identified upon their plates. Those in all probability restricted to the higher zones I have marked with an asterisk.

Tetragraptus fruticosus, <i>Hall.</i>	Phyllograptus typus, <i>Hall.</i>
Didymograptus Murchisoni, Beck.*	— angustifolius, <i>Hall.</i>
— geminus, <i>His.</i>	Climacograptus Scharenbergi*, <i>Lapw.</i>

*America.*—As pointed out by Professor Selwyn §, the main mass of the Point-Levis or Quebec group of the valley of the St. Lawrence lies at the very base of the Ordovician or Lower Silurian system, and is thus, broadly speaking, synchronous with the British Arenig rocks. Its Rhabdophora have been long familiar to the eyes of palæontologists in the beautiful plates of Hall's classical memoir on the Graptolites of the Quebec Group. It may be that the more ancient of the strata from which his specimens were procured may eventually be proved to be of true Cambrian age. In the meantime, however, no division of these forms can be attempted. The species figured by Hall from Point Levis include:—

Clonograptus flexilis, <i>Hall.</i>	Didymograptus bifidus, <i>Hall.</i>
— rigidus, <i>Hall.</i>	— indentatus, <i>Hall.</i>
— abnormis, <i>Hall.</i>	— extenuatus, <i>Hall.</i>
— ramulus, <i>Hall.</i>	— constrictus, <i>Hall.</i>
Loganograptus Logani, <i>Hall.</i>	— arcuatus, <i>Hall.</i>
Dichograptus octobrachiatus, <i>Hall.</i>	— extensus, <i>Hall.</i>
Tetragraptus Headi, <i>Hall.</i>	— pennatulus, <i>Hall.</i>
— alatus, <i>Hall.</i>	Phyllograptus typus, <i>Hall.</i>
— crucifer, <i>Hall.</i>	— iliciformis, <i>Hall.</i>
— quadribrahiatus, <i>Hall.</i>	— angustifolius, <i>Hall.</i>
— denticulatus, <i>Hall.</i>	Diplograptus dentatus, <i>Brongn.</i>
— bryonoides, <i>Hall.</i>	— inutilis, <i>Hall.</i>
— Bigsbyi, <i>Hall.</i>	Climacograptus antennarius, <i>Hall.</i>
Didymograptus nitidus, <i>Hall.</i>	Trigonograptus ensiformis, <i>Hall.</i>
— patulus, <i>Hall.</i>	Retiograptus tentaculatus, <i>Hall.</i>

† Boeck, 'Bemærkninger angaaende Graptolitherne:' Christiania, 1851.

‡ Scharenberg, 'Ueber Graptolithen:' Breslau, 1851.

§ Selwyn, Canadian Naturalist, 1879, p. 17.

From similar beds at Orleans Island, Gros Maule, and the river St. Anne, Hall describes:—*Didymograptus similis*, H.; *Tetragraptus fruticosus*, H.; *T. Headi*, H.; *Dichograptus octonarius*, H.; *Clonograptus Richardsons*, H.; and *Phyllograptus Anna*, H.

Of these Quebec forms *Tetragraptus Headi*, H., *T. bryonites*, H., *Phyllograptus angustifolius*, H., and *P. typus*, H., were subsequently detected in corresponding strata on the coast of Newfoundland\*, where their association with Crustacea &c. of Tremadoc and Arenig types, as at Point Levis, is demonstrative of their systematic place at or near the base of the Ordovician.

*Australia*.—Mr. R. Etheridge, Jun., and Professor M'Coy have recently described a small collection of Rhabdophora from the lowest Ordovician rocks of Australia†, which is remarkable for its general identity in facies with that of the Arenig rocks of England and Canada. The species figured are possibly:—

*Loganograptus Logani*, Hall.  
*Goniograptus Thureaui*, M'Coy.  
*Tetragraptus bryonoides*, Hall.  
 — quadribrachiatus, Hall.  
 — fruticosus, Hall.

*Dichograptus octobrachiatus*, Hall.  
*Phyllograptus typus*, Hall.  
*Retiograptus tentaculatus?*, Hall.  
*Didymograptus Pantonii*, M'Coy.  
 — nitidus, Hall.

together with indeterminable species of *Climacograptus* and *Diplograptus*.

#### *Llandeilo Formation.*

Dr. Hicks breaks up the Llandeilo formation of Wales into three portions, the well-known limestones and calcareous shales of Llandewi Felfry and Llandeilo forming the central member. This arrangement, though not universally applicable, may possibly be the natural one in the southern districts. There the Lower Llandeilo consists of dark carbonaceous shales and thick beds of coarse sandstones, with occasional igneous rocks of contemporaneous age, the Middle Llandeilo of calcareous flagstones, and the so-called Upper Llandeilo of soft dark grey flags and mudstones, forming a gradual transition into, and only doubtfully separable from, the overlying Bala formation.

In the Lower Division, as seen to the west of Shelve, I have collected *Didymograptus Murchisoni*, Beck, in some abundance, and in corresponding strata below as well as

\* Logan and Billings, *Geology of Canada*, pp. 291, 293, 872.

† R. Etheridge, Jun., *Annals and Mag. Nat. Hist.*, July 1874; M'Coy, *Prodromus Palaeontology Victoria*, decades i., ii., and v.

amid the volcanic rocks of the Gelli Hills near Builth. In the dark Llandeilo shales of Pwllacca near Llandeilo I have seen the smaller varieties of *Didymograptus Murchisoni* in myriads, together with *Diplograptus foliaceus*, Murch., *Climacograptus cælatus*, Lapw., and indeterminate forms of *Didymograptus*. *Didymograptus Murchisoni*, Beck, is quite as abundant in the black shales below the Limestone of Llandewi Felfry near Whitland, associated with *Didymograptus Nicholsoni*, Lapw., *Goniograptus*, sp., *Climacograptus confertus*, Lapw., *Diplograptus tricornis*, &c. The forms recognized by Mr. Hopkinson and myself\* in the Lower Llandeilo zone of Abereddy Bay include

*Didymograptus euodus*, Lapw.  
 ——— indentatus, Hall.  
 ——— Murchisoni, Beck.

*Diplograptus foliaceus*, Murch.  
 ——— tricornis, Carr.  
*Dicellograptus moffatensis*?, Carr.

and some others.

In the Middle Llandeilo of Abereddy Bay are found *Dicellograptus*, *Diplograptus foliaceus*, Murch., and *D. tricornis*, Carr. In the corresponding strata of Builth Road and Wellfield, Radnorshire, I have detected

*Dicellograptus patulosus*, Lapw.  
*Cœnograptus gracilis*?, Hall.  
*Diplograptus foliaceus*, Murch.

*Diplograptus tricornis*, Carr.  
*Climacograptus cælatus*, Lapw.

A fine example of *Dicranograptus formosus*, Hopk., from these beds at Castell is in the Jermyn-Street collection (Case iv.  $\frac{5}{3}$ ). Rocks of corresponding age at Meadowtown near Shelve have yielded me *Diplograptus foliaceus*, Murch., and *D. dentatus*, Brongn.

The Upper Llandeilo rocks of Abereddy Bay have, up to this time, proved barren of Graptolites. From the Upper Llandeilo of Hagley, near Chirbury, I have collected *Diplograptus foliaceus*, Murch., and *Climacograptus Scharenbergi*, Lapw. From the Upper Llandeilo of Llandrindod Wells Mr. Hopkinson sent me, some years ago, *Climacograptus Scharenbergi*, Lapw., *C. cælatus*, Lapw., and *Dicellograptus moffatensis*, Carr. From the same rocks near that town I have this summer collected *Diplograptus tricornis*, Carr., *D. foliaceus*, Murch., *Climacograptus cælatus*, Lapw., *C. perexcavatus*, Lapw., *C. Scharenbergi*, Lapw., and species of *Dicellograptus* and *Lasiograptus*.

At the village of St. Clear's, near Caermarthen, the bank of the little river exposes a good section of highly fossiliferous

\* Hopkinson and Lapworth, Quart. Journ. Geol. Soc. vol. xxxi. p. 634.

black shales, apparently of Upper Llandeilo age. In these I have recognized

*Dicranograptus formosus*, *Hopk.*

— *sextans*?, *Hall.*

*Diplograptus foliaceus*, *Murch.*

*Climacograptus cælatus*?, *Lapw.*

— *perexcavatus*, *Lapw.*

During the progress of the Geological Survey of North Wales Mr. Salter detected Graptolites in the deep-seated schists of Tiddyn Dicwm, near Tremadoc. From their apparent stratigraphical position he assigned them to the general horizon of the Arenig formation. There can be little doubt, however, that they are actually of Llandeilo age. The specimens from this locality preserved in the Jermyn-Street Museum, or figured in the 'Geology of North Wales'\*, include *Dicranograptus ramosus*, Hall, *Diplograptus tricornis*, Carr., *Climacograptus Scharenbergi*, Lapw., and *C. bicornis*, Hall. I recognized the same species in a fine collection made by Mr. Hopkinson from this locality in 1873, together with the following additional species:—

*Didymograptus*, sp.

*Glossograptus Hincksi*, *Hopk.*

*Diplograptus dentatus*, *Brongn.*

*Diplograptus angustifolius*, *Hall.*

*Dicellograptus sextans* (?), *Hall.*

*Diplograptus Whitfieldi*, *Hall.*

*Ireland.*—The only graptolitiferous strata in Ireland that can with certainty be assigned to the Llandeilo formation are the schists of Bellewston Hill, County Meath, whence Mr. Baily procured *Didymograptus Murchisoni*, Beck, in association with *Diplograptus foliaceus*, Murch., and other forms †.

*Sweden.*—The black shales that overlies the Orthoceras-Limestone of Sweden, and are known as the *Dicranograptus*- or Middle Graptolite-schists, fall into two tolerably distinct palæontological groups. The lower group (*Murchisoni*- or *geminus*-schists) is marked by the presence of *Didymograptus geminus*, His., and several allied species; and it may therefore be roughly paralleled with our British Llandeilo. According to the most recent researches of Mr. Linnarsson ‡ its lowest beds contain representatives of the British forms *Phyllograptus typus*, Hall, *Diplograptus Hopkinsoni*, Nich., and *Diplograptus tricornis*, Carr. These pass up into a group of dark shales with *Didymograptus geminus*, His.; and the Llandeilo group is terminated by beds with *Glossograptus Hincksi*, Hopk. With the above forms occur also Diplo-

\* *Memoirs Geol. Surv. England and Wales*, vol. iii. pl. xii.

† Baily, *Journ. Geol. Soc. Dublin*, Jan. 1862.

‡ Linnarsson, 'Öfversigt af Vetenskaps-Akademiens Förhandlingar,' 1878.



graptidæ of the genera *Diplograptus* and *Climacograptus*, together with *Lasiograptus* and *Azygograptus* &c.

*France* &c.—*Didymograptus Murchisoni* and its allies occur in the inferior division of the Schiste ardoisier of Bretagne \* in association with Crustacea of Llandeilo type. It is found also in similar strata near Oporto in Portugal †.

[To be continued.]

XXXIX.—*Description of a new Species of Acme and Varieties from the Conglomerate Beds at Menton.* By GEOFFREY NEVILL, C.M.Z.S.

*Acme Foliniana.*

Testa turrito-elongata, imperforata, cornea, lævis et nitida; spira subrecta, paululum prope apicem obtusum eversa; anfract. 6 aut  $6\frac{1}{2}$  (rarissime 7), convexiusculi, sutura distincta separati, interdum inferne linea incisa (more *Eulimidarum*) circumdata; apertura subverticalis, subquadrangularis, marginibus callo lævi junctis; columellaris subrecta; peristom. album, percrassum, duplex.

Typi anfr. 6.5; long. 5.5, diam. 1.75; apert. alt. 1.5, lat. 1.1 millim.

This was an exceedingly abundant form, often in a perfect state of preservation, at three different levels; a few specimens had seven well-developed whorls, the others 6 or  $6\frac{1}{2}$ , increasing very gradually and regularly, moderately convex, the last two approximately of equal breadth; apex blunt and obtuse, the apical whorls with a slight inclination to the right (away from the axis of the shell); perfectly smooth, polished, shining, of a more or less pale horny colour, sometimes so transparent that the columella can be traced from the apex to the base; suture distinct, with a more or less obsolete incised line close below it, as in many species of *Eulima* &c.; aperture a trifle everted, subquadrate, with a remarkable, pure white, callous rib close to the peristome, imparting a duplex appearance to the latter; a thin callosity joins the margins.

I have much pleasure in naming this, the giant of its genus, after my friend the Marquis de Folin of Bayonne, whose researches connected with minute marine species are so highly valued and appreciated.

\* Tromelin and Lebesconte, 'Catalogue des Fossiles Siluriens,' 1875, p. 46, &c.

† Sharpe, "Geology of Neighbourhood of Oporto," Q. J. G. S. vol. v. p. 147.